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DEVELOPMENT OF AN EDUCATION PROGRAM FOR REGISTERED NURSES
RELATED TO THE USE AND FUNCTION OF MECHANICAL
PROPHYLAXIS IN VTE PREVENTION

by

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Abstract

Venous thromboembolism events (VTE) are one of nine hospital-acquired events monitored by organizations, such as The Joint Commission, that are considered preventable when the proper safeguards are in place. Practice recommendations by the National Institute for Health and Care Excellence and The American College of Chest Physicians include adhering to pharmacological and nonpharmacological therapy for at risk patients. In patients with contraindications to pharmacological prophylaxis, mechanical therapy provides adequate protection against VTE when used correctly. Registered nurses within the acute care setting are key players in ensuring that mechanical therapy is implemented and maintained at the bedside. The purpose of this quality improvement project was to assess nurse understanding on the use and function of mechanical prophylaxis. The project included a pretest, educational program, and posttest design on a surgical unit at Rhode Island Hospital. The Logic Model Framework guided the quality improvement project. Twenty-one nurses completed the pretest (66%) and 21 attended the educational sessions and completed the posttest (66%). Pretest scores ranged from 2.4 to 4.2 out of a possible 5 points for each question, with a mean response rate of 3.6. In comparison, posttest scores ranged from 3.5 to 4.6, with a mean response rate of 4.3. The average posttest response rate increased by 0.7 points. Seventeen nurses completed a program evaluation (n=17; 60%). Three themes were derived after analysis of open ended responses by nurses from the program evaluation. Overall, the findings supported increased understanding on the use and function of mechanical prophylaxis by nurses after attending the educational program. Further research is needed to determine if incorporating this educational program in new hire orientation or developing a formal nursing policy on mechanical prophylaxis would increase nurse and patient compliance.

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Table of Contents

Background/Statement of the Problem	1
Literature Review.....	4
Theoretical Framework.....	33
Method	35
Results.....	42
Summary and Conclusions	48
Recommendations and Implications for Advanced Nursing Practice	52
References.....	55
Appendices.....	60

Development of an Education Program for Registered Nurses related to the Use and Function of Mechanical Prophylaxis in VTE Prevention

Background/Statement of the Problem

When patients are admitted to the hospital to undergo a surgical procedure, they are entrusting healthcare providers to leave them in better condition than when they arrived. During the postoperative period, the diligence of the healthcare team in preventing unnecessary injury is equally important as maintaining sterile technique. Venous thromboembolism events (VTE) are among the many complications considered to be preventable. Deep vein thrombosis (DVT) and pulmonary embolism (PE) are blood clots that arise from immobility, injury, and prolonged hospitalization. Vichow's Triad explains the pathophysiology of clot formation as the product of venous stasis, vessel injury, and coagulation abnormalities (Nettina, 2010). When the deep vessels of the leg develop a clot, it has the potential to break off and travel to the lungs where it can cause significant harm or even death. Increased age, obesity, pregnancy, hormone therapy, malignancy, trauma, and prolonged hospitalization related to surgery endorses clot formation. Persons with these risk factors are at high-risk of a VTE event including fatal PE (Sprizza & Witko, 2003).

According to the Centers for Disease Control (CDC), 900,000 Americans are affected by VTE, resulting in 100,000 premature deaths and \$10 billion in healthcare costs each year. Hospital-acquired VTEs account for half of persons diagnosed with blood clots and it is estimated that 70% of VTEs are preventable (2016). The Joint Commission has teamed up with the Centers for Medicaid and Medicare to combat

venous thrombosis events with a goal to reduce hospital-acquired VTE by 40% nationally (Agency for Healthcare Research and Quality, 2015). Professional organizations such as the American Heart Association, the American College of Chest Physicians (Geerts, Bergqvist, & Pineo, 2008) and the Association of Perioperative Registered Nurses (AORN) (Wicklin, 2011). provide guidelines for VTE prevention for healthcare providers. These organizations urge the development and use of protocols to identify high-risk patients and to reduce practice variation among providers. The implementation of the Affordable Care Act makes quality of care a top priority. When providers take every measure to prevent complications, VTE prophylaxis can contribute to higher revenue for facilities and better outcomes for patients.

Despite the evidence supporting the need for formal protocols on VTE prophylaxis, compliance with professional recommendations is poor (Dunn & Ramos, 2017). For patients without contraindications, a multimodal approach of pharmacological and mechanical prophylaxis is encouraged. For those patients who cannot receive pharmacological prophylaxis due to risk of bleeding, including those with hemorrhagic stroke, trauma, or thrombocytopenia, strict mechanical prophylaxis is imperative in preventing DVT (National Institute for Health and Care Excellence, 2010). Registered nurses provide direct patient care and serve as advocates to ensure patients receive quality care. Educating patients on the importance of mechanical prophylaxis and promoting its use starts and ends with nurses. Nurse adherence with mechanical prophylaxis directly impacts patient outcomes. Nurses must be equipped with adequate tools and knowledge on how to care for at risk patients. By taking a closer look at current practices of VTE prevention, among nurses caring for post-operative and trauma patients,

knowledge deficits can be identified and remediation can begin. The purpose of this project was to assess nurse understanding on the use and function of VTE prophylaxis, specifically mechanical prophylaxis.

Next, a review of the literature will be discussed.

Literature Review

A comprehensive literature review was completed and included searches without timeline restrictions. Search engines utilized included PubMed and CINAHL and the following keywords were searched: DVT; DVT prophylaxis; nurse role; patient compliance; surgical patients and DVT; trauma patients and DVT; incidence and prevalence; and mechanical prophylaxis. The literature review will provide an overview of the following areas: VTE definition, pathophysiology, diagnosis and clinical manifestations, economic burden of VTE, incidence and prevalence of VTE for high-risk patients, practice guidelines, comparison of devices, understanding and knowledge of VTE prevention in patients, nurses, and physicians, and nursing role and implications in VTE prevention.

VTE: Definition, Pathophysiology, Clinical Manifestations, and Diagnosis

Definition and Pathophysiology. Deep vein thrombosis and pulmonary embolism are jointly termed as venous thromboembolism (VTE) events (Grossman & Porth, 2014). Deep vein thrombosis is the formation of an occlusive clot, most commonly to the veins of the leg, causing an inflammatory response in the vessel wall. A fat or blood embolism that breaks off and travels to the pulmonary artery and impairs ventilation and/or perfusion to the lungs is known as a pulmonary embolism (Grossman & Porth). Venous thromboembolism is characterized as clot formation occurring in the superficial and deep in veins of the limbs and involving embolism to the lungs. Venous stasis and endothelial injury resulting from prolonged bed rest, trauma, surgery, child birth, fractures of the hip and femur, MI, congestive heart failure, and spinal cord injury

promote activation of the coagulation process (Grossman & Porth). In the clotting cascade, factor X converts the protein, prothrombin, to thrombin. Thrombin then acts as an enzyme to convert fibrinogen to fibrin, which begins the development of a clot. The coagulation process is initiated by either intrinsic or extrinsic factors and can occur slowly or within seconds following a vessel wall injury (Grossman & Porth).

Hypercoagulability states can be caused by inherited disorders, such as Factor V Leiden in which regulatory antithrombic mechanism are lost or acquired in events that cause disturbed blood flow leading to platelet and clotting factor congestion, as seen in immobilized patients (Grossman & Porth). Thrombosis occurring in the deep veins of the leg, including the common iliac, femoral, great saphenous, and popliteal vein are more worrisome than clot development in the distal veins. The deep veins of the leg, specifically those above the knee, are more prone to leading to fatal pulmonary embolism and post-thrombotic syndrome (Bonner & Johnson, 2014).

Clinical Manifestations of DVT. Common signs and symptoms of DVT include severe pain, fevers, chills, malaise, swelling, cyanosis of the effected arm or leg, and unilateral edema. If the clot is extensive, lymphedema and arterial compromise can be present (Nettina, 2010). Presence of a positive Homan's sign, pain upon dorsiflexion of effected limb, is no longer considered a reliable indicator for DVT (Anthony, 2013). Post-thrombotic syndrome (PTS) or valve insufficiency is the most common complication of DVT and causes lifelong pain, swelling and heaviness of the leg (Bonner & Johnson, 2014).

Diagnosis of DVT. Diagnosis of DVT includes assessment of patients' signs and symptoms with weighed risk factors (Bonner & Johnson, 2014). The use of the Wells

Score and trending d-dimer levels is widely supported in screening for possible DVT. The Wells Score measures clinical features associated with DVT and assigns them a numerical score. Localized tenderness, documentation of a swollen leg with at least 3cm difference between symptomatic and asymptomatic leg are examples of the clinical features assessed in a Wells Score. If a patient scores a 2 or greater on a Wells score and have a positive d-dimer test, DVT is likely. Confirming diagnosis by ultrasound is the gold standard (Bonner & Johnson). Other diagnostic test that may be used are impedance plethysmography, radioactive fibrinogen testing, venography, and coagulation studies. In the event DVT is confirmed, assessing the patient for potential PE is essential and should be routinely monitored (Nettina, 2010).

Pathophysiology of PE. Pulmonary embolism is the obstruction of blood flow to the pulmonary artery causing impaired perfusion and gas exchange of the lungs (Grossman & Porth, 2014). Thrombus occurring in the deep vessels of the leg are most often the cause of PE. Like DVT, individuals are at increased risk of PE if they have had recent orthopedic surgery or cancer, or are pregnant or using oral contraceptives, and have developed thrombosis related to venous stasis, injury, or hypercoagulability (Grossman & Porth). Hemodynamic changes seen in patients with PE include increased pulmonary vascular resistance and pulmonary pressures, right-sided heart failure, and decreased blood pressure and cardiac output leading to shock (Nettina, 2010).

Clinical Manifestations and Diagnosis of PE. Chest pain, tachycardia, dyspnea at rest, increased respiratory rate, hypoxemia without hypercarbia, and a sense of impending doom are found in persons with PE (Grossman & Porth, 2014). Patients may also have a productive cough of blood-tinged sputum and fever. In fatal PE, patients quickly become

unconscious with a rapid weak pulse, low blood pressure, and distended neck veins.

Definitive diagnosis is determined by clinical signs and symptoms, presence of venous thrombosis, and results of blood gases, troponin, d-dimer, and CT of the chest (Grossman & Porth). Ventilation-perfusion (V/Q) scanning and pulmonary angiography are also used for more definitive diagnosis when needed (Nettia, 2010).

Economic Burden of VTE

In a retrospective, observational, parallel, comparative cohort study, the economic burden of DVT, PE and post-thrombotic syndrome (PTS) was determined by analyzing patient claims using PharMetrics Patient-Centric Database (MacDougall, Feliu, Boccuzzi, & Lin, 2006). Inclusion criteria included patients enrolled in benefits 12 months prior to the initial event and throughout the study period from January 1, 1997 to March 3, 2004. Patients with a diagnosis of DVT or PE prior to the study period were retained to determine rates of recurring rates of VTE. Patients were divided into subgroups: diagnosis of DVT and PE alone and DVT and PE combined. Patients with no evidence of DVT or PE diagnosis were used as the control group. Patients with persistent pain and swelling 6 months after diagnosis of DVT were included in the PTS group.

A total of 169,640 patients had evidence of DVT and PE and 26,958 met the inclusion criteria. Fifty-nine point six percent (n=16,063) had a diagnosis of DVT, 29.3% (n=7,889) had PE, 11.2% (n=3,006) had both PE and DVT and 3.8% (n=663) had confirmed diagnosis of PTS. Annual healthcare cost was found to be higher in persons diagnosed with DVT (\$7,227), PE (\$6,831), and DVT and PE subgroups (\$6,771) compared to the control group (\$1,045). Out-patient pharmacy related cost were also

significantly higher for DVT/PE subgroups: \$3,645 versus \$600 for the control group. Patients with PTS had an additional annual healthcare cost of \$11,667 (32%) compared to other subgroups. The average time to develop PTS was 258 to 208 days after diagnosis of DVT (MacDougall et al.).

Patients in the identified subgroups spent more money related to physician office visits, emergency room encounters, imaging studies, and diagnostic imaging. Patients were often diagnosed with DVT/PE on average 40-52 days after hospitalization and those with greater comorbidities and repeated surgical procedures after diagnosis were more likely to have suffered from PTS. Patients with a history of diabetes, cardiovascular disease, cancer, and orthopedic or abdominal surgery had increased incidence of DVT/PE. Females were also at increased risk and the average age diagnosed was 52-54 years old (MacDougall et al.).

Several limitations were noted in the study. This study only included patients 65 and older that were enrolled in Medicare risk plans. Patients within this group differ from their cohorts in terms of demographics, access to care, and severity of disease. Indirect cost, including lost wages and productivity, were not included in the overall cost analyzed by researchers. If included, this would support an even greater financial burden of VTE. Lastly, without the availability of ICD-9 codes for PTS, researchers used algorithms to determine the rate of PTS and its cost burden. Researchers relied solely on documentation of patient manifestations of leg swelling and pain to determine potential PTS. Using this method could underrepresent the number of those effected by PTS.

In a retrospective study by LaMori, Shoheiber, Mody, and Bookhart (2015), the economic burden of inpatient treatment of VTE was determined by analyzing the national database Nationwide Inpatient Sample (NIS). The Nationwide Inpatient Sample represents the largest database of hospital care data and collects information on over 1,000 hospitals within the United States. All patients with a primary discharge diagnosis of DVT or PE within 2011 and within the 10 participating states were included (LaMori et al.). Participating states included California, Florida, Iowa, Maine, Mississippi, Nebraska, New Mexico, New York, Vermont, and Washington.

A total of 330,044 patients were diagnosed with VTE during a hospital stay during 2011. A total of 143,417 (43.3%) were diagnosed with DVT and 186,627 (56.5%) with PE. Patient characteristics associated with a DVT diagnosis included males (n=67,900; 47.3%), greater than 65 years of age (n=78,221; 54.5%), hypertension (n=66,117; 34.4%), disorders of lipid metabolism (n=46,022; 23.9%), and disorders of fluid, electrolytes and acid-base balance (n=27,946; 14.5%). Patient characteristics associated most commonly in PE diagnoses included males (n=86,745; 46.5%), persons aged less than 65 (n=95,929; 51.4%), hypertension (n=87,016; n=52.8%), disorders of lipid metabolism (n=63,785; 38.7%), and disorders of fluid, electrolyte and acid-base balance (n=46,383; 28.2%) (LaMori et al.).

The mean length of stay (LOS) for DVT was 4.7 days and was associated with a mean hospital cost of \$30,051 compared to PE with a mean LOS of 5.1 days and overall cost of \$37,006. Of the patients diagnosed with DVT, 22,142 (15%) had multiple readmissions related to DVT with 3.3% (n=757) occurring within the same month as the primary diagnosis. In comparison, of the number of patients diagnosed with PE, 31,463

(16.8%) had multiple readmissions related to PE with 3.3% (n=1080) occurring within the same month as the first diagnosis. Patients with recurrent episodes of DVT are at increased risk of post-thrombotic syndrome. Recurrent VTE, leading to PTS is linked to poorer quality of life, missed days of work, and disability (Kachroo et al., 2012). While more than 50% of the patients diagnosed with VTE in 2011 were discharged home, patients were also discharged with either skilled homecare nursing services or to skilled nursing facilities (La Mori et al.). Although the cost of these services was not determined in this study, they contribute to the overall financial burden of treating a VTE diagnosis.

Incidence and Prevalence of VTE for High-Risk Patients

While VTE events can often go undetected in the asymptomatic patient, the prevalence of post-hospital VTE events is a compelling reason for providers to keep prophylaxis as a priority during and after a hospital stay. In a prospective observation study by Ambrosetti et al. (2004), patients admitted to cardiac rehabilitation after coronary artery bypass graft surgery (CABG) were monitored for DVT/PE. Researchers aimed to calculate DVT cases and predictive factors associated with the development of DVT, such as length of stay, timing of heparin injections, comorbidities, and the use of graduated compression stockings on bilateral or ipsilateral extremities of the lower limbs. Patients with a previous history of VTE, other cardiac surgery, or receiving anticoagulation for reasons including atrial fibrillation and mechanical valve were excluded.

After excluding factors, 290 patients were included in the study. Patients were admitted to the rehabilitation unit 4 to 19 days after surgery and 35 patients had a history

of prolonged immobility, greater than three days and a length of stay greater than eight days (Ambrosetti et al., 2004). Patients were scanned on day two and day seven of admission. A DVT was found in 47 (17.4%) of patients with 49% (n=23) being diagnosed on the first scan and contralateral to saphenous vein graft site. Pulmonary embolism developed in two patients, one resulting in fatality. Compression stockings were prescribed for 74% (n = 200) of the patients. However, 14% (n =28) had a recorded delay in therapy from three hours to three days, seven percent (n=18) had received bilateral compression therapy, and 26% (n=70) received no mechanical prophylaxis. Lastly, 18% (n=50) of patients received subcutaneous heparin injections until the day of discharge. Females, history of cancer, postoperative complications, and obesity were some of the patient characteristics found in patients diagnosed with DVT in this study. Patients in this study did not receive routine diagnostic testing for PE as they did for DVT. A limitation to this study is the potential for a higher reported value of PE as patients can often be asymptomatic. Additionally, the results cannot be generalized to all CABG patients as it evaluated only those who were admitted to a rehabilitation center. Varying practices of pharmacological and mechanical practices greatly impact the incidence and prevalence of VTE events in the postsurgical patient. Delayed care in the hospital setting has lasting effects during the rehabilitative phase as demonstrated in this study (Ambrosetti et al.).

In a prospective study by Davenport, Vargas, Kasten, and Xenos (2012), predictive factors in developing in hospital and post discharge VTE after colorectal cancer resection were determined using the database, The American College of Surgeons National Surgery Quality Improvement Program (ACS NSQIP). The database stored

information on over 200 hospitals performing any major general surgery. Researchers collected information on patient characteristics, intraoperative processes of care and adverse outcomes including DVT and/or PE during the hospital stay and 30 days post discharge. The exact time of data collection or hospital admission dates were not stated. Post-discharge information was collected through phone calls, letters, and medical records obtained from hospitals and clinics. Patients less than 16 years of age and undergoing additional surgery within the 30-day period were excluded.

A total of 21,943 patients underwent colorectal cancer resection. Deep vein thrombosis developed in 217 (1.0%) of patients in-hospital and in 89 (0.4%) post-discharge. Pulmonary embolism developed in 120 (0.5%) of patients during a hospital stay and 60 (0.3%) developed 30 days post-discharge. The median time of diagnosis after discharge was nine days with 60 (44%) diagnosed with either DVT or PE. The average length of stay was seven days. Post-discharge VTE risk started on post-operative day (POD) five and continued to increase until week three.

Patient characteristics predictive of a hospital acquired VTE included a history of coronary heart disease (CAD), advanced age, cancer, race including people of black descent, males, increased BMI, and decreased hematocrit. Persons aged 71-80 were among the highest subgroup to develop a hospital acquired VTE with an odds ratio of 2.77, followed by a having a history of CAD (OR 2.13), cancer (OR 1.68), black origin (OR 1.56), BMI >35 (OR 1.52), males (OR 1.43), and a preoperative hematocrit level < 38% (OR 1.37). Steroid use to manage a chronic condition was found to be a predictive factor in development of post-discharge VTE with an incidence rate of 2.6% (n=575). The study does not state whether VTE prophylaxis was used during hospitalization on

this patient population. It is also possible that the rate of VTE could be higher as part of the postoperative data collection was subject to missed phone calls and unanswered letters from patients. Similar to the findings of Ambrosetti et al. (2004), this study demonstrates the need for continued prophylaxis after a hospital for at risk patients. Major surgery combined with comorbidities and abnormal hematologic processes seen in cancer patients makes this population ideal candidates for prolonged prophylaxis after surgery (Davenport et al.).

In a retrospective chart review by Wei, Li, Pei, Shen, and Li (2016), preoperative D-dimer levels were evaluated to determine their use as a predictive test to identify developing DVTs in patients undergoing posterior lumbar interbody fusion (PLIF). Patients with a diagnosis requiring lumbar fusion and who had surgery between the dates of March 2008 to November 2014 were included in the review. Patients who had evidence of bleeding including, hematuria, positive fecal occult blood, skin purpura, hematoma and/or fractures, infection, and tumor were excluded. Other exclusion factors were high risk of bleeding, allergies to anticoagulants, and previous history of DVT. Preoperative D-dimer levels were obtained in all of the patients and a blood plasma concentration of 0.50 ug/ml were considered a predictive sign

Patients received both pharmacological and mechanical prophylaxis in this study. Mechanical prophylaxis was started preoperatively until the patient was ambulatory. Pharmacological prophylaxis, using low-molecular weight heparin LMWH, was given daily starting on post-operative day one until day seven. For patients with positive D-dimer levels preoperatively, these patients received a dose of LMWH 12 hours prior to surgery. On post-operative day five, patients began to ambulate. Ultrasounds were

performed within 24 hours of hospital admission and on post-operative day five. If patient developed symptoms related to DVT, they were scanned again.

After excluding criteria were applied, 2,861 patients were included in the study. Patients were separated into two groups, the DVT positive group (n=269) and the DVT negative group (n=2592). Of the DVT positive group, 252 (97.3%) developed a DVT involving the distal veins and 17 (6.3%) developed a DVT in the proximal veins. Of the positive D-dimer group (n=201), 112 (55%) developed a DVT. Other prevalent history associated with DVT included hypertension (n=137, 50.9%), coronary heart disease (n=102, 37.9%), rheumatoid arthritis (RA) (n=31, 11.5%), and major surgery (n= 82, 32%) compared to the no DVT group with a surgical rate of 25% (n=648). In addition, advanced age was associated with increased likelihood of DVT, with the average age of the DVT group at 61.3 years and the no DVT group at 52.6 years. In this study, all of the patients received a combined mechanical and pharmacological prophylaxis with an overall rate of 9.4% who developed a DVT. More importantly, 0.5% (n=17) of the entire group developed a proximal DVT, which is a risk factors of PE (Wei et al.). Despite these low rates, patients at increased age with a history of heart disease, RA, and undergoing surgery were more likely to develop a venous thromboembolism event in this study. Incorporating assessing risk into preoperative testing, such as measuring D-dimer levels and assessing comorbidities, can lead to heightened awareness and stronger prevention against VTE (Wei et al.).

Practice Guidelines

In January 2010, the National Institute of Health and Care Excellence (NICE) released clinical guidelines on reducing VTE events for hospitalized patients. NICE identifies assessing risk of VTE and bleeding as key priorities. Surgical and trauma patients with a procedure involving an anesthetic time for more than 90 minutes, or 60 minutes if the surgery involved the lower limbs, an expected significant reduction in mobility, and one or more risk factors, are at increased risk of VTE (NICE). Persons with active bleeding, acquired bleeding disorders, or those already anticoagulated with an INR greater than 2, lumbar puncture or spinal anesthesia expected within 12 hours or received within four hours, acute stroke, thrombocytopenia, uncontrolled hypertension, or untreated inherited bleeding disorders are at high risk for bleeding and should not receive pharmacological prophylaxis (NICE). Both NICE and the American College of Chest Physicians (Geerts, Bergqvist, & Pineo 2008) support the use of mechanical prophylaxis, i.e. elastic stockings and compression devices, in the event anticoagulation is contraindicated. Inferior vena cava filters should be used in patients with contraindications to both mechanical and pharmacological prophylaxis (NICE).

Sequential compression devices, including foot pumps, should be selected to meet the individual needs of patients while considering possible contraindications to the devices (NICE, 2010). Patients should be educated on the purpose of therapy and encouraged to wear the devices as much as possible when in bed and sitting in the chair. The Agency for Healthcare Research and Quality (2016) recommended patients undergoing major orthopedic surgery and with contraindications to anticoagulants to have 18 or more hours of mechanical therapy a day with the use of sequential compression devices. In other surgical patients associated with high-risk of VTE and bleeding, IPC

must be used until the risk of bleeding has subsided. Healthcare professionals are responsible for properly fitting the patients and monitoring for complications. When patients no longer have reduced mobility, the devices may be discontinued. Reduced mobility is defined by NICE as a patient who is bedbound, unable to walk unaided or likely to spend a substantial proportion of the day in bed or in a chair (NICE). The American Perioperative Registered Nurses Association (Wicklin, 2011) provides practice recommendations for the perioperative nurse in DVT prevention. The AORN supports the development of DVT prevention protocols with a multidisciplinary approach, including nurses. Incorporating VTE risk assessment in the perioperative RN's assessment can promote adherence to practice recommendations. The AORN believes that by having the proper devices, with various sizing readily available, compliance with mechanical devices will be positively impacted. In addition, contacting the manufacturer to schedule product in-services can promote proper use of the devices. Lastly, enlisting the help of advanced practice nurses to support and educate staff nurses can encourage nursing autonomy (Wicklin).

Comparison of Mechanical Devices

In a study comparing the effectiveness of foot pumps alone and in combination with graduated compression stockings (GCS) in patients post total hip replacement (THR) and total knee replacement (TKR), researchers sought to determine if foot pumps alone had greater efficacy in DVT prophylaxis (Pitto & Young, 2008). Patients were divided into two groups, those using both GCS and foot pumps (n=400) and those using foot pumps only (n=400). Although not statistically significant, patients receiving foot pump therapy alone had a lower incidence of DVT (2.3%; n=9) versus the stocking group

(2.7%; n=11). Proximal DVTs developed in two (0.5%) of the no stocking group and in three (0.75%) of the stocking group. All DVTs were in the operated extremity and 45% (n=9) were diagnosed after discharge. Nonfatal PE developed in two of the no stocking group and two of the stocking group (0.5% vs 0.5%). Eliminating the use of GCS did not impact the incidence of DVT in these postsurgical patients. Patients in the no stocking group were more likely to comply with mechanical therapy with only 4% (n=16) asked to have the foot pumps turned off during their hospital stay compared to 7.5% (n=30) of the stocking group asking to have their foot pumps discontinued. In addition, the 205 patients treated with mechanical prophylaxis alone using the foot pumps showed significant reduction in wound drainage, minor wound bleeding, bruising, and oozing of the wound. This study demonstrates the safety and efficacy foot pumps offer for the TKA and THR patient as opposed to GCS which are more often improperly fitted and poorly received by patients.

The use of mechanical devices in high-risk patients with contraindications to anticoagulation has shown to provide a safe and effective alternative to DVT prophylaxis. Compression stockings (GCS), sequential compression devices (SCD) and foot impulse pumps are all forms of mechanical prophylaxis. The effectiveness of these therapies has been studied alone and in combination with pharmacological prophylaxis. In a stratified meta-analysis by Ho & Tan (2013), 16,164 hospitalized patients from 70 different trials were analyzed in comparing the effectiveness of alternative compression therapies alone and in combination with pharmacological interventions. The trials involved 15 countries and were held on orthopedic surgery, general surgery, urology, neurosurgical, critical care, gynecological surgery, and cardiac surgery units. Researches searched the databases

Cochrane Library control trial register from 2012, EMBASE from January 1988 to February 23, 2013 and MEDLINE from February 1966 to February 12, 2013. Key words search included “pneumatic compression,” “sequential compression,” “external compression,” “intermittent compression,” or “pumps” with “venous thromboembolism,” “deep vein thrombosis,” or “pulmonary embolism” (Ho & Tan, 2013). Randomized control trials comparing the effect of compression therapy to no compression therapy, TEDS alone, pharmacological therapy alone, and a combination of mechanical and pharmacological therapy in hospitalized patients were included in the review. Trials that used compression therapy for less than 24 hours after surgery, compared devices without a control group, and those not reporting VTE as an outcome were excluded from the study.

In analyzing 40 trials that compared the effect of intermittent pneumatic compression (IPC) versus no IPC, patients had a total risk reduction of 9.4% of developing DVT and 1.6% of PE when IPC was used. In comparing compression therapy to TEDS alone, nine trials showed a relative risk of DVT of 0.61 and relative risk of PE of 0.64 when compression therapy was used independently. Lastly, IPC was shown to be as effective as pharmacological prophylaxis in reducing DVT and PE with a relative risk of 0.93 and 1.19 respectively. Compression therapy alone had a relative risk of bleeding of 0.41. Combined, the use of IPC and pharmacological thromboprophylaxis revealed a relative risk of DVT of 0.54 and PE of 0.62. It was determined that the cost savings of using compression therapies (\$180) versus the burden of treating PE (\$20,000) was noteworthy. Compression therapy has been shown to be the least invasive intervention to protect patients against VTE events. When the risk of bleeding lessens for the

postsurgical and trauma patient, a combination of compression therapy and pharmacological prophylaxis provides optimal protection for high-risk patients (Ho & Tan).

Surgery to the lower limbs, soft tissue injury, and trauma are often barriers to implementing compression therapy to the limbs. In Imbrahim, Ahmed, Mohamed, & Abduo's 2015 systematic review, literature on the effectiveness of sequential compression devices (SCD) in preventing DVT among trauma patients was reviewed. The databases PubMed, Cochran Library, and CINHALL were searched from the years of 1990 to 2014 using the key words "prevention," "DVT," "sequential compression devices," and "trauma patients." The search was completed from March of 2014 to June of 2014 (Imbrahim et al., 2015). Randomized control trials (RCT), studies including persons 18 years or older, trauma patients with blunt or penetrating trauma, and trauma patients who received mechanical prophylaxis using SCDs or intermittent pneumatic compression (IPC) or foot pumps were included in the review. Studies including children, acute spinal injuries, and non-trauma were excluded from the search. As a result, five randomized control studies were used in the final review.

A total of 1,072 patients were involved in the five trials. Four of the trials were conducted in the United States and one trial in Canada. Two trials tested the effectiveness of SCDs to no mechanical prophylaxis and found reduction of DVT rates in the SCD group. The incidence of DVT of the prophylaxis group was 2.9% compared to 8.8% of the no prophylaxis group. In the second study, the incidence of VTE in the no prophylaxis group was 11.3% and 4% in the prophylaxis group. These results were found to be statistically significant. The remaining studies compared thigh-calf sequential

compression devices to the foot pumps and found varying results between the two devices. One study found the incidence of DVTs in thigh-high compression to be 1.6% versus 4.8% in the foot pump group. In a similar study comparing thigh-high and foot pump devices, lower incidence was found in the foot pump versus thigh-high compression therapy (9% vs 19%). The statistical significance is not disclosed comparing the two devices. In addition, thigh high compression therapy was associated with a larger occlusive clot and pulmonary embolism compared to the foot pump group who did not develop a PE. The difference between the two devices in developing a large clot were statistically significant ($p=16$). Patient demographics, past medical history, timing of therapy, or length of hospital stay were not disclosed in this systematic review. Therefore, risk factors and limitations to the studies cannot be identified. However, the five RCT largely support the use of mechanical prophylaxis in trauma patients as evidence by lower DVT rates. In addition, this systematic review supports the use of foot pumps as an alternative for compression therapy (Imbrahim et al.). Their ease of use and compatibility with orthopedic patients often makes foot pumps superior to SCDs and TEDS in some surgical and trauma patients.

Understanding and Knowledge of VTE Prevention in Patients, Nurses, and Physicians

When nurses are provided with evidence-based information on the importance of mechanical therapy and parameters for its use, compliance rates are positively impacted (Stewart, Zalamea, Waxman, Schuster, & Bozuk, 2006). Stewart et al. observed all surgical patients admitted to a community hospital who had an order for compression therapy for compliance. In this observational study, patients admitted to the surgical

service and had an order for SCDs were included. Patients were observed on day of admission until discharge. Researchers monitored for compliance with SCDs twice daily. Compliance was defined as SCDs applied to both lower extremities with the pump turned on. The observational period occurred for two months. Patients and nurses were blinded from the study and the observations occurred during resident surgical rounding. After the observational period, one surgical unit was chosen and nurses on this unit received education on the purpose and benefits of SCDs. Informational flyers were also handed to patients which requested that patients reapply their own SCD after ambulation or notify a nurse to reapply the device (Stewart et al., 2006). An additional two-month observational period began after the education was completed.

After the education was completed, compliance rates were significantly higher (65%) compared to other units who had not received the education (48%). It was noted in this study that surgical units had a greater compliance rate compared to nonsurgical units overall 61.5% vs. 48%. Nurses within the study that are more familiar with mechanical therapy and its purpose are more likely to use the devices in daily practice. Routine education and monitoring for compliance creates an expectation of care and could be the answer to better compliance rates (Stewart et al.).

In a quantitative, cross-sectional survey by LeSage, McGee, & Emed (2008), researchers aimed to identify how hospitalized patients attained knowledge on VTE and their current perspectives on thromboprophylaxis. A 16 closed-question and 5 open-question questionnaire was formulated to investigate patient knowledge of VTE and patient perspectives on pharmacological thromboprophylaxis. Four major themes were derived after analyzing patient responses. These themes included patient knowledge of

pharmacological thromboprophylaxis, DVT and PE, how patients learned about the conditions, patient satisfaction with thromboprophylaxis, and how patients preferred to receive information on thromboprophylaxis. Patients were randomly selected using the hospital pharmacy database from August 2007 to October 2007. Patients 18 years of age or older who received pharmacological thromboprophylaxis for a minimum of three days were included in the study. Patients admitted to the ICU, were cognitively impaired and/or confused, had orthopedic surgery, or were healthcare professionals were excluded from the survey. Patients either completed the questionnaire independently or a student researcher read the questions aloud and record participant responses.

After inclusion criteria and initial recruitment, 48 patients participated in the survey with a 60.8% response rate. Adults ranging from 29-93 years participated and received pharmacological intervention for an average of 13 days. Of the sample, 22 (45.8%) received both pharmacological and nonpharmacological prophylaxis; 10 (45.5%) treated with compression stockings and 12 (54.5%) with stockings and intermittent pneumatic compression (IPC). Twenty-six (54.5%) had not received any form of mechanical prophylaxis. Surgical patients accounted for 56.2% (n=27) of the participants and 27.1 % (n=13) were medical. The remaining patients had an admitting diagnosis of oncology or palliative care. Over half of the participants were aware that they were receiving pharmacological prophylaxis for blood clots (n=39, 83.3%). In addition, 39 (81.2%) had heard of both DVT and or PE and 9 (18.7%) had never heard of either condition. In assessing further knowledge, 41.9% (n=12) could state that DVT was a blood clot originating from the legs and could state leg swelling and pain as a common sign and symptom and 20% (n=9) could not identify any symptoms. However, only three

participants, 6.25% of the original group, could identify PE as a major complication of DVT. In addition, only one participant stated leg exercises could prevent DVT.

Immobility, obesity, and flights traveling 6 to 12 hours were the most commonly reported risk factors among the participants. Of the participants who heard of DVT and/or PE, participants reported receiving their knowledge of VTE most commonly from family members or friends (n=18, 58.1%), followed by TV/Newspaper (n=4, 12.9%), physician (n=8, 25.8%), and nurse (n=5, 16.1%). Other reported sources included pamphlet, another patient, physiotherapist, pharmacist and other. Participants were asked two open-ended questions to assess how they would like to receive information on VTE and optimal timing for education. Thirty-seven patients responded to these questions and 18 (48.6%) preferred written material and 13 (35.1%) wished to receive education directly from the nurse. Of the 13 who wished to receive information from the nurse, three (8.1%) believed the best time for education was at the time of pharmacological intervention. Venous thromboembolism poses as much of a risk as secondary infections and psychosocial distress for all hospitalized patients. Patients with long hospital stays are vulnerable to complications and should be informed by their healthcare providers in order to receive the most accurate information. As displayed in this study, hospitalized patients lack knowledge on this topic and its potential dangers. This implicates a need for nurses to maintain competence on VTE prevention and keep patient education a top priority (LeSage et al.).

While educating patients is imperative to positive outcomes, assessing and understanding barriers to optimal VTE prophylaxis among healthcare providers is vital. Time management and misconceptions about adequate VTE prophylaxis contribute to

noncompliance of DVT prophylaxis in healthcare providers (Kaur et al., 2012).

Noncompliance with mechanical prophylaxis is identified as failure to (a) initiate therapy, (b) resume after interruption or (c) provide continuous therapy until appropriate. Kim and Lee (2014) interviewed 29 surgical intensive care unit nurses on current practices of mechanical therapy. As part of a larger study comparing the efficacy of compression stockings and IPC in preventing DVT among 147 surgical intensive care patients, nurses working on the ICU were included in the secondary survey. In the survey nurses were asked about the problems they experienced in maintaining mechanical therapy and were given the opportunity to openly write about personal experiences.

The most reported problems in applying and maintaining compression stockings were applying stockings to a patient with decreased level of consciousness (n=14; 48.3%) and the concern for skin breakdown around the ankle and thigh (n=13; 44.8%). In applying IPC, failure to sustain the Velcro part of the sleeve was reported as a deterrent in mechanical therapy (n=15; 51.7%) and patient complaints of discomfort often prohibited therapy (n=6; 20.7%). Other difficulties in maintaining mechanical therapy included limited sizing available, difficulty in sizing patients appropriately, and trouble mobilizing patients with IPC equipment. Kim and Lee found that nurses wanted more information on appropriate and minimum application time of mechanical devices, the effectiveness of devices in preventing DVTs, and the difference in the effectiveness between devices in combination and independently. While this sample size is small, it highlights important barriers nurses face in providing safe and competent care. Organizations are responsible for implementing safeguards to promote the likelihood of healthcare providers in making the right decision versus a poor one. By addressing

educational needs and providing the inventory needed to care for all patients, usage of prevention will be more likely to be incorporated into practice (Kim & Lee).

In a 2013 street survey, researchers used four open ended questions to assess the general public's knowledge on DVT in Birmingham, UK (Boulton, Fenton, Loka, Sharif, & Greenfield, 2015). Using their questionnaire, every fourth person on the street was interviewed throughout the week. Persons less than 18 years of age, worked as a healthcare professional, and those who had a history of DVT, or had a relative or friend with a history of DVT were excluded from the survey. Responses were recorded in addition to socioeconomic and demographic information, including gender, age, ethnicity, and occupation.

A total of 304 participants were included in the study. The largest subgroup of respondents included females (n=173; 56.7%), persons aged 60-69 (n=64; 21.1%), ethnicity of white origin (n=232; 76.3%), and were professionally occupied (n=110; 36.2%). Seventy-one percent (n=216) responded that risk factors, such as lifestyle, flying, immobility, and past medical history contributed to a higher risk of development of DVT. Sixty two percent (n=186) knew at least one complication of DVT and only 8.8% (n=26) knew that DVT could lead to fatal pulmonary embolism (Boulton et al., 2015). Preventative methods including medication, the use of compression stockings, and activity were stated in 73.4% (n=233). In comparing demographic characteristics, females had a higher mean total of correct response to males (5.09 vs. 4.07), the 30-39 age group had higher mean totals than older and younger age groups (5.48 vs. 3.76) and people of white ethnicity scored better compared to those of non-white ethnicity groups

(1.49 vs. 1.11). Lastly, knowledge gaps were largest between professionally employed and unemployed participants (5.59 vs. 3.60).

This street survey illustrates the need for greater public awareness on venous thromboembolism and its complications. Together, males, people of non-white ethnicity, the old and young populations and the unemployed were identified as vulnerable populations related to their poor knowledge. Twenty-four percent (n= 73) had no knowledge of potential complications of DVT and 25% (n=77) could not state at least one preventative measure against DVT (Boulton et al., 2015). People that are informed are more likely to actively participate in their care and report signs and symptoms of DVT (LeSage et al., 2008). National campaigning of VTE can heighten awareness and is a public health initiative that can be life-saving.

Nursing Implications in VTE Prevention

Assessing for possible signs and symptoms of DVT in the post-surgical and trauma patient should be anticipated by nurses. While 40% of individuals with DVT are asymptomatic, a thorough nursing assessment can prevent the burden of VTE (Race & Collier, 2007). Noted unilateral edema and stretched or firm skin are indicators of possible DVT. Assessing differences in temperature from ankles to calves on affected and unaffected limbs also assists in identifying to possible thrombosis. The affected limb will be cooler to touch and larger in size. Recording leg circumference daily should be nursing responsibility (Nettina, 2010). Nurses can alert physicians when the affected leg is significantly larger than the unaffected leg, making a case for further assessment and intervention by the provider. Although less common, assessing for DVT of the upper

extremities is essential. Rotating intravenous catheters and monitoring for infiltration can prevent escalation of care and development of DVT (Nettina).

Assessment of PE includes a comprehensive respiratory assessment, including monitoring work of breathing, respiratory rate, and auscultation of adventitious lung sounds (Nettina, 2010). Flushed skin and tachycardia may occur in the presence of fever. Unilateral swelling, pain, and tenderness are suspicion for DVT and a primary cause of PE. A sudden change in mentation or anxiety can indicate thrombosis. Lastly, monitoring coagulation studies and noting subtherapeutic PT/INR as the potential cause for PE is a nursing intervention that can be lifesaving (Nettina).

Nursing Role in VTE Prevention

Prevention is the best defense against DVT. Nurses are in the position to ensure adequate prophylactic measures are in place for their patients. The administration of pharmacological prophylaxis using low-molecular weight heparin or unfractionated heparin in addition to mechanical prophylaxis is ideal in the prevention of DVT (American College of Chest Physicians, 2008). For patients at risk for bleeding, mechanical prophylaxis using TED stockings and compression devices, including calf, thigh-high, and foot impulse devices provide optimal therapy. Manufacturer guidelines provide directions on indications and contraindications of use. Caring for and sizing patients receiving mechanical therapy is also provided (Covidien, 2011b).

When using TED stockings, the thickest part of the calf and the distance from the heel to the popliteal fossa (knee pit) should be measured. The stocking should terminate 1-2" below the knee cap (Covidien, 2011a). Sequential compression devices and foot

pumps should also be sized correctly - choosing small, medium, or large as needed.

Contraindications to mechanical therapy includes dermatitis, vein ligation (immediate postoperative), gangrene, recent skin graft, severe arteriosclerosis or ischemic vascular disease, massive edema of the legs, pulmonary edema from congestive heart failure, or extreme deformity. Suspicion for DVT or history of DVT, thrombophlebitis, or PE are contraindications to using compression devices. The patients skin integrity should be check routinely and per hospital policy (Covidien, 2011b).

In patients with contraindications to pharmacological prophylaxis, mechanical therapy, and early mobilization serves as their only defense against VTE. Appropriate sizing, application of mechanical devices, and monitoring for complications are all responsibilities of the registered nurse. Inconsistencies are found in nurses caring for patients with mechanical therapy (Brady et al., 2007). Brady et al. conducted an observational and survey study designed to determine whether knee-length or thigh-length TEDs and SCDs were more likely to be correctly applied and worn by patients. Patients were also surveyed on their knowledge of the rationale of why these devices were being used, the level of comfort between the different devices, and the length of time patients wore the devices each day. Six surveyors identified and randomly selected patients with an order for TEDs and/or SCDs. Patients aged 18 years of age and older with the ability to complete a 15-minute survey were included in the study. Confused patients, prisoners, restrained patients, or patients with an acute psychiatric illness were excluded from the survey. Data collection occurred from the fall of 2003 to the winter of 2005.

A total of 137 patients were included in the study. During observations, the surveyors found 117 patients in bed and only 29.2% (n=40) had their SCDs on. In 26 (47%) patients that had SCDs ordered, no machine was present in the room. Of the patients that had either knee or thigh high SCDs on, 26 (65%) out of 40 had them correctly applied. In the remaining patients with SCDs on, problems were found related to improper fitting or improperly fastened Velcro. Noncompliance was found in 91 (66%) of the patients ordered for SCDs. Patients wearing thigh-high compression devices were more noncompliant than knee high compression devices patients (53% vs. 32%). Discomfort with the devices (n=35; 39%), just completing personal care and/or walking (n=41; 46%), failure of the nurse to initiate therapy or replace device upon transfer from another unit (n=11; 13%), and not being aware device was off (n=2, 2%) were listed as reasons for noncompliance. Upon observing compliance with TED stockings, 62.8% (n=86) were found wearing stockings and 37.2% (n=51) were not. Like SCDs, patients responded for reasons for not complying with TEDs related to discomfort with the devices (n=30; 59%), just completing personal care and/or walking (n=11; 23%), failure of the nurse to initiate therapy or replace device upon transfer from another unit, (n=8; 16%) and not being aware the stockings were off (n=1; 2%). Patients wearing thigh-high complained more about discomfort than knee-high stockings (n=43; n=5 respectively). Problems with fit were found greater in thigh-high stockings, with the most common problem found to be the stocking creating a tourniquet or rubber band effect of the leg (Brady et al., 2007). In this study, DVT prophylaxis ordering was inconsistent, formal VTE prevention policy did not exist, and units were often inadequately supplied with equipment. Despite this, noncompliance with mechanical prophylaxis should not be

related to nurse's failure to implement or resume therapy. Sizing, application of devices and stockings, and monitoring for comfort and complications is a nursing responsibility. This hospital later revised their hospital policy and discontinued the use of thigh-high TEDS and SCDs related to their high risk of improper fitting and risk for complications (Brady et al.).

Elder et al. (2016) explored potential causes for the variation in VTE pharmacological prophylaxis on low performing and high performing units at Johns Hopkins Hospital using a mixed-method approach. The study included direct observation of nurses on the administration of pharmacological VTE prophylaxis. In the first part of the study, nurses were observed as they prepared low-molecular weight heparin (LMW), offered the injection to the patient, and administered the injection. Nurses were informed at the beginning of their shift that observations were taking place on their units. Nurses working on inpatient units and caring for a patient with an order for pharmacological prophylaxis were included in the observation. Nurses and patients gave formal consent to participate. In addition to observation, researchers used surveys to learn more about nurse attitudes and beliefs regarding VTE prophylaxis. Six high performing and six low performing units were targeted. A six question Likert Scale was used to survey the nurses and were confidential. Unit surveys were collected as a whole to compare compliance rates with specific unit beliefs and attitudes towards prophylaxis.

Of the 299 surveys distributed, 248 (83%) were completed. Response rates on low performing and high performing units were similar, 118 (87%) low and 130 (80%) from high performing units. It was found that nurses on high performing units were on their units for a shorter period of time than low performing units (5.5 years vs. 7.6 years).

Nurses on low performing units were more likely to use their clinical judgement to determine when to omit doses of pharmacological prophylaxis compared to high performing nurses (n=94; 80% vs. n=65; 50%). However, nurses on both units agreed that avoiding pain and bruising often outweighed the benefit of pharmacological prophylaxis. Several themes were also emerged from the nurse and patient interaction.

Nineteen nurse and patient interactions were observed in this study. Six themes were identified using data from the direct observations and focus groups led by the researcher during shift change. Among the six themes identified, nurse belief in prophylaxis as discretionary and presenting it to patients in this manner was most prominent, and tended to influence the process and rate of administration of pharmacological prophylaxis. Although the research does not provide actual comparison of the rates of pharmacological administration between low and high-performing units, the authors concluded that factors such as personal beliefs and nurse experience affect the rate of administration of pharmacological prophylaxis. Sixty-five (50.1%) of surgical nurses and 93 (79.5%) of medical nurses reported that they use their clinical decision-making skills to determine when to omit unnecessary doses of prescribed DVT/PE prophylaxis injections for each patient. Surgical units with lower nurse to patient ratios were among the six high performing units. It was also found that nurses tended to focus on ambulation status as reason for withholding doses without regard for other risk factors (Elder et al., 2016), which demonstrates a lack of understanding and value on the importance of VTE. Periodic education and remediation can support best practice and eliminate attitudes and beliefs from guiding decision making.

Incorporating VTE prevention in multidisciplinary rounds and assessing specific patient risk factors can promote nurse understanding on the importance of prophylaxis (Elder et al., 2016). Nurses must be provided with guidelines on the duration of mechanical therapy, contraindications of its use, and when it is appropriate to discontinue therapy. Without these guidelines, nurses will tend to use clinical judgement alone in decision making and unknowingly provide sub therapeutic care (Elder et al., 2016). In summary, nurses must be diligent in protecting patients from unnecessary harm, which includes adhering to strict mechanical prophylaxis in high-risk patients. Making mechanical prophylaxis a standard of care and integrating it into nursing practice can promote adherence and accountability. It can also heighten awareness among inexperienced nurses that may not care for surgical patients routinely. Supporting nurses through education can help clarify misconceptions, allow for hands-on practice, and provide a platform for learning.

Next, the theoretical framework guiding this project will be discussed.

Theoretical Framework

The Logic Model of Program Development, developed by the Kellogg Foundation (2004), guided the study in developing a nurse-tailored program on the importance of adequate VTE prophylaxis. The Logic Model is defined as a model that systematically and visually presents the researcher's understanding of the relationship among the resources one must have to operate a program, the intended activities of the program, and the changes or results expected by the developer (Kellogg Foundation). Easy to understand diagrams are used to clearly state what the researcher plans to do and why. The researcher's planned work and intended results are displayed in a pictorial fashion in which the resources/inputs, program activities, outputs or immediate goals, and long-term goals are displayed (Kellogg Foundation). The Logic Model serves as a blueprint for the program developer and can change over time as enabling factors permit. Figure 1 on the next page illustrates the Logic Model Framework.

The resources or inputs are the resources one must use to develop the program and direct the work. The activities are the interventions used to bring about intended goals. The short-term and long-term goals are displayed as outputs, outcomes, and impact. Outputs are the immediate changes seen as the result of the program. Transformed behavior or knowledge is demonstrated in outcomes and the impact is the overall organizational change expected by the program developer. Achieving organizational change is a timely process and may take up to several years. (Kellogg Foundation, 2004).

Next, the methodology for this quality improvement project will be presented.

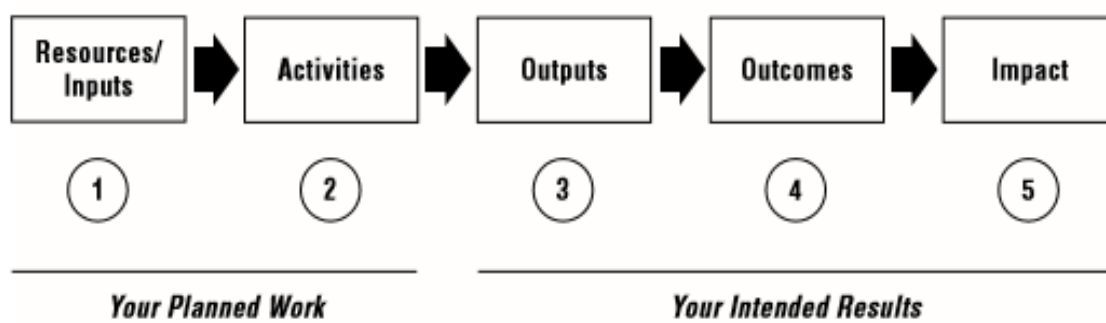


Figure 1. The Logic Model Framework

Method

Purpose

The purpose of this project was to assess nurse understanding on the use and function of VTE prophylaxis, specifically mechanical prophylaxis.

Design

This program development project included a pretest, intervention, and posttest design. The pretest determined current VTE prevention knowledge and practices among staff nurses working on a surgical floor and served as a needs assessment. Based upon the findings of the pretest, an educational program was developed to educate nurses on the use and function of mechanical prophylaxis. A posttest was administered after the program to measure improved competency. A program evaluation form was provided to participants for feedback and to ensure the project met the stated learning objectives.

Sample and Sites

Nurses at Rhode Island Hospital, a Brown University affiliated teaching hospital, working on a designated surgical and trauma unit, COOP 3, were included in the study. After accounting for medical leaves and absences, there were 32 active registered nurses on the unit. The pretest, program, and posttest occurred on the designated unit.

The Logic Model Framework

Resources/Inputs. Nurses working on the COOP3 of Rhode Island Hospital caring for the post-surgical and trauma patient were the targeted group receiving the education. Clinical guidelines from the National Institute of Health and Care Excellence

(2010) and the American College of Chest Physicians (Geerts, Berqvist, & Pineo, 2008) guided the content presented in the program and served as best practice standards. In addition, direct input from a vendor representative resulted in information that was incorporated into the program. The program developer collaborated with the advanced practice nurses working within quality and safety at Rhode Island Hospital, to review content and assisted as experts on this topic.

The need for nurse education on proper mechanical prophylaxis was identified through routine observation by a Trauma Nurse Practitioner and a Physical Therapist at Rhode Island Hospital. TEDs and SCDs were found to be incorrectly sized, not being used while patients were in bed and sitting in chairs, and were receiving an inadequate amount of time of mechanical therapy. There was also a rise in DVT rates on this unit which prompted further investigation by quality and safety personnel, including a Certified Nurse Specialist (CNS) designated to the unit. This quality improvement program was aimed toward reinforcing the importance of mechanical therapy, and the education of nurses on their expected role in managing and educating patients who required mechanical prophylaxis.

Activities/Procedures. An informational letter explaining the purpose of the program and intended goals was displayed on the specified unit one week prior to surveying the nurses. This letter was also sent as an e-mail attachment to weekly updates that were distributed by the assistant clinical manager every Friday. The letter explained the program's purpose: To increasing nurse understanding on the use and function of mechanical prophylaxis. Nurses were informed that participation in the program, including completion of the pre and posttest, was voluntary.

The pretest (Appendix A) was available in the lunchroom for nurses to complete anonymously. An envelope containing copies of the survey was placed on the table with an attached informational letter explaining the purpose of the program. A locked box was available for completed surveys. For one week, the box remained on the unit so that nurses on alternative shifts could complete the survey at any time.

Activities/Program Development. A program geared toward nurses working with populations at high-risk of VTE on the proper use and function of mechanical prophylaxis was developed. Content included: general nursing knowledge of mechanical therapy; discussion of alternative SCD devices and contraindications to using devices; proper sizing; required patient care and education; nurse documentation of device usage; and parameters for appropriate discontinuation. Table 1 describes the content, behavioral objectives, and time allotted throughout the program to meet stated objectives. Prior to implementation, the program developer met with Medtronic, the vendor of the sequential compression devices (including the A-V foot impulse devices), to review and clarify content of the program. Information shared during this meeting was incorporated into the educational program.

Table 1

Program Content, Objectives and Time Frame

Content Outline	Behavioral Objectives	Time Frame
Introduction: Brief review of the pathophysiology of VTE and importance of mechanical therapy in high-risk patients.	State the purpose of mechanical therapy.	5 minutes
Present manufacturer sizing chart and discuss application of both SCD and A-V foot impulse devices.	Demonstrate proper sizing and application of devices.	5 minutes
Evaluate the manufacturer error key chart, discuss most common alarms and appropriate action to remedy the alarms.	Demonstrate how to activate and troubleshoot devices.	10 minutes
List contraindications to mechanical therapy.	Describe contraindications to using mechanical therapy.	3 minutes
Discuss skin care required for patients receiving mechanical therapy, including monitoring skin integrity at a minimum of every 8 hours repositioning dependent patients every 2 hours.	Describe the expected patient care required for patients receiving mechanical therapy	5 minutes
Emphasize the need for a mechanical therapy order by licensed independent practitioner (LIP) prior to implementing therapy. Briefly review computerized documentation within LifeChart, including documentation of devices within the flowsheet each shift, applying VTE prophylaxis in care plan, and providing written education for patients using Clinical References.	Describe the necessary nursing documentation required when using mechanical therapy, including addressing care plans and confirming LIP order.	5 minutes
Review best practice for mechanical therapy timing as outlined by the NICE.	Describe timing for appropriate discontinuation of mechanical therapy.	5 minutes

Nurses were allotted time for hands-on experience with the devices during which a demonstration on proper use and troubleshooting occurred. The program was tailored to meet the scheduling needs of registered nurses and included 30-35 minute sessions at 1400 and 2200 every day for one week. Nurses on COOP 3 work eight hour shifts and the nurse manager determined that these hours provided the most potential free time to participate for nurses and supported maximum participation. Nurses were presented with written material covering both SCD and foot pump devices. A poster presentation was used during each session to review the program content as outlined in Table 1. Each nurse also received informational cards with key information, such as a sizing chart, frequent alarms and troubleshooting the devices.

Outputs/Measurement. The goal was to have all nurses working on the designated unit participate in the program and complete the pre and posttest.

Nurses were asked to complete a pre and posttest (Appendix A & B) developed by the program developer that included a Likert response format. The test was developed to assess staff nurses' knowledge and current practices on the use of mechanical prophylaxis. The measurement tool was developed by the program developer and the content of the scale was reviewed in collaboration with a nurse researcher at Rhode Island Hospital. The scale was influenced by Elder et al.'s (2016) research, which attempted to discover if nurses' beliefs and attitudes affected the compliance with administration of pharmacological prophylaxis. Although the content is different, this study used a Likert Scale to survey the nurses and had a successful response rate. Elder et al. also found that nurses with less years of experience had greater compliance with pharmacological prophylaxis. For this reason, the Likert Scale used in this project will

also assess years of experience and length of time in current position to determine if they impact compliance rates with mechanical prophylaxis. The scale was pretested for understanding and readability by a second advanced practice nurse and several Master's-level nursing students. Two questions on the scale were revised for clarity after it was reviewed. Parameters investigated included general nursing knowledge, alternative SCD devices, patient education, documentation of device usage, and parameters for appropriate discontinuation.

The effectiveness of the program was evaluated in a 10 question Likert Scale posttest (Appendix B), which was identical to the pretest. Nurses were asked if they participated in the pretest to correlate response rates before and after the intervention.

Outcomes. The short-term outcome of the program was to increase nurse understanding on the use and function of mechanical therapy. Though beyond the scope of this project, the long-term goal is to increase nurse and patient adherence with mechanical thromboprophylaxis. A goal of 100% compliance rate with mechanical prophylaxis is the intended long-term goal. Providing nurses with information on how to attain resources and equipping them with evidence-based knowledge can encourage nurse autonomy and further support change.

Program Evaluation

Participants had the opportunity to evaluate the program. The Rhode Island State Nurses Association Program Evaluation Form was utilized (Appendix C).

Data Analysis

The data were analyzed by applying a weighted scale to the Likert questions in both the pre and posttest. A strongly disagree response was scaled for 1 point, disagree=2, neutral=3, agree=4, and strongly agree=5. The mean response for each question was calculated and displayed in a graphical chart, comparing the pre and posttest responses.

Next, the results will be discussed.

Results

Twenty-one out of a possible 32 nurses (n=21; 66%) participated in both the pre and posttest, for a 66% response rate, and also attended the educational session. Seventeen nurses (80%) of the 21 who participated in the program completed a program evaluation.

Years of experience were used to divide nurses into three groups: 0-5 years; 6-10; and greater than 10 years of experience. One pretest survey was incomplete and was not included in the data analysis. In the pretest, 16 nurses (80%) comprised the 0-5 group, 2 (10%) were in the 6-10 group, and 2 (10%) made up the greater than 10 group. Fourteen nurses (67%) comprised the 0-5 group in the posttest, 4 (19%) were in the 6-10 group, and 3 (14%) made up the greater than 10 years of experience group.

Figure 2 demonstrates the mean response rates, after applying a weighted scale to the survey, comparing pre and posttest results.

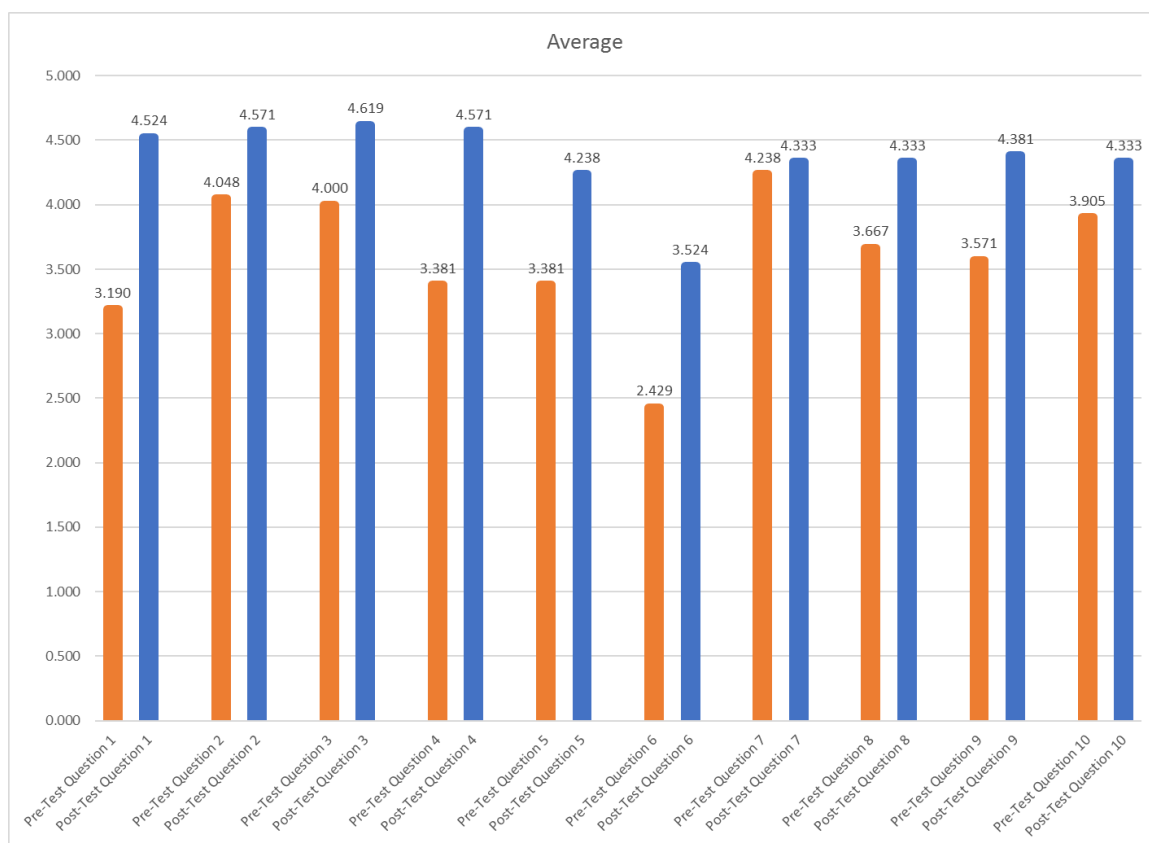


Figure 2. Comparing pretest and posttest mean response rates

There was an overall improvement in posttest scores compared to pretest scores. Pretest scores ranged from 2.4 to 4.2 out of a possible 5 points for each question, with a mean response rate of 3.6. In comparison, posttest scores ranged from 3.5 to 4.6, with a mean response rate of 4.3. The average posttest response rate increased by 0.7 points.

Three questions showed the greatest improvement in the posttest analysis. Question one had a mean response rate of 3.1 in the pretest, compared to 4.5 in the posttest. More nurses agreed that they had received formal training on sequential compression devices after the educational session, with a 1.3 increase in response rate. Question four, “I am familiar when to use foot pumps as an SCD device,” improved by

1.2. Pretest response rates averaged 3.4 while posttest rates illustrated improved learning with a mean response rate of 4.6. Lastly, question six was noteworthy for enhanced learning. The mean pretest response rate was 2.4, compared to 3.5 in the posttest. After the educational sessions, nurses were more likely to agree that patients sitting in the chair should have their SCD device maintained. This change was signified by the 1.1 increase in the posttest average.

Figure 3 and Figure 4 illustrate the pre and posttest response rates by the number of nurses who answered strongly disagree, disagree, neutral, agree, and strongly agree for each question.

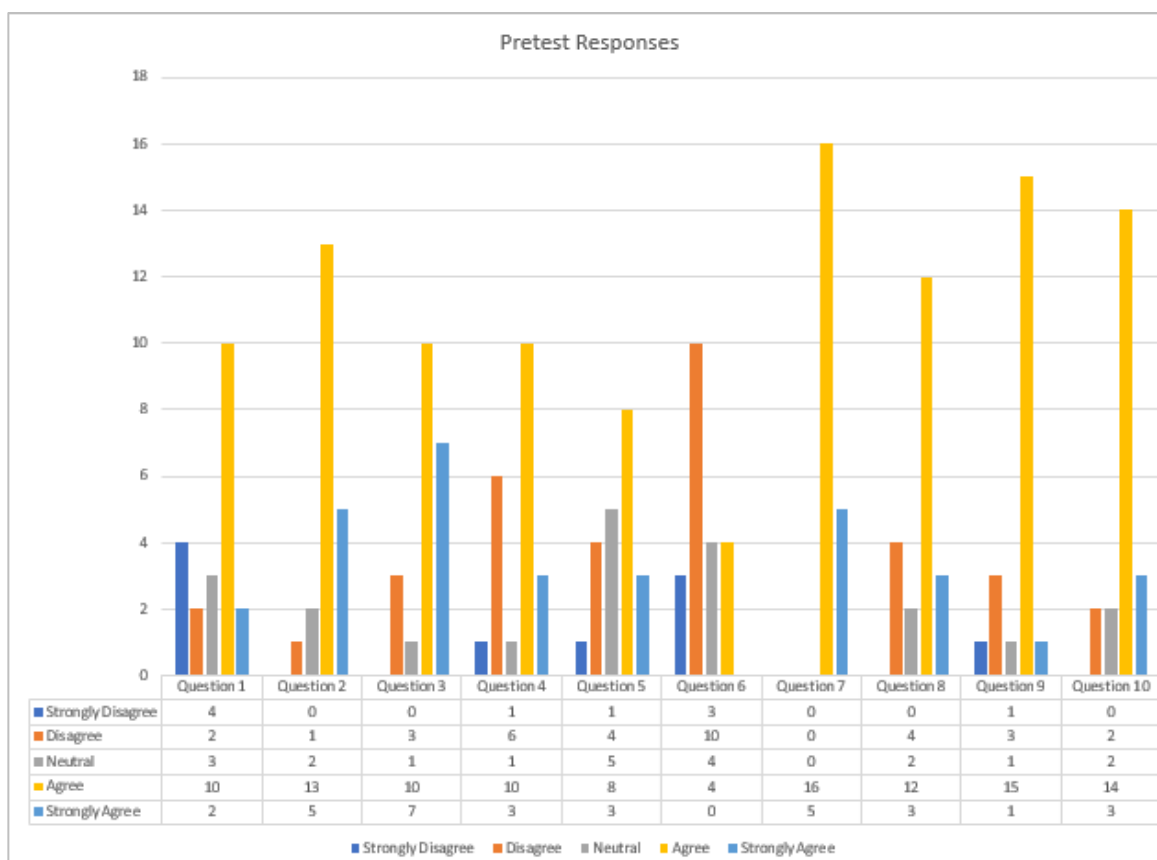


Figure 3. Pretest response rate

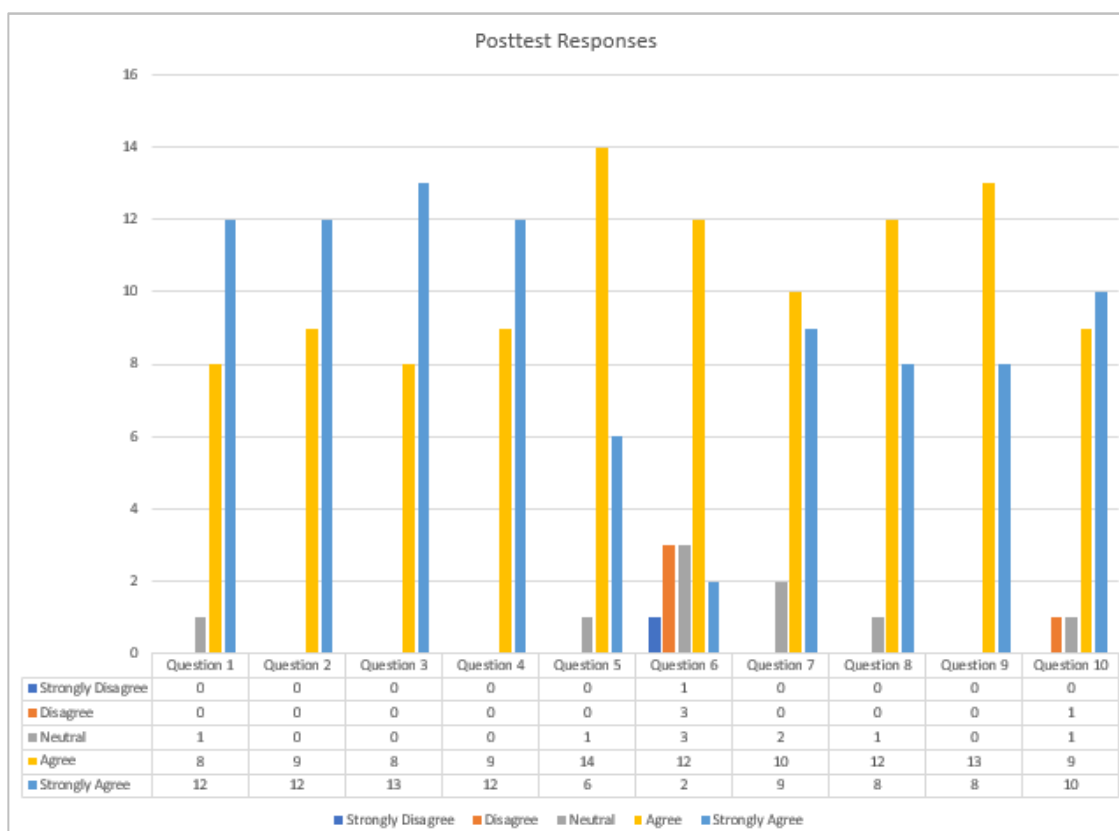


Figure 4. Posttest response rates

The pretest responses illustrate nursing practice prior to implementing education on mechanical prophylaxis. In survey question one, 19% of nurses (n=4) strongly disagreed that they had been formally trained on the use of sequential compression devices, while 47% (n=10) agreed and 10% (n=2) strongly agreed. Fourteen percent (n=3) were neutral on this topic. In the posttest, none of the nurses surveyed had strongly disagreed or disagreed that they were formally trained on SCD devices. Thirty-eight percent (n=8) and 57% (n=12) agreed and strongly agreed that they had received formal training after the education sessions. Nurses in the 0-5 years of experience group demonstrated the greatest increase in competency. Half of the nurses (n=9; 56.3%) had

agreed responses in the pretest, while 100% (n=14) agreed in the posttest that they were formally trained on the use of compression devices.

Question four provided an even greater divide between agree and disagree responses. Thirty-three percent of nurses (n=7) had disagree responses while 62% (n=13) had agreed that they were familiar when to use foot pumps as an SCD device. In the posttest, 100% (n=21) of the nurses either agreed (n=9, 43%) or strongly agreed (n=12, 57%) that they were familiar with foot pumps as an SCD device. When compared to the 0-5 years of experience group, nurses in the 6-10 and >10 groups had greater experience with foot pumps prior to the education sessions. All nurses surveyed in groups 6-10 (n=2, 100%) and >10 (n=2; 100%) had agreed in the pretest that they were familiar with foot pumps as an alternative compression device compared to only 56.3% (n=9) of the 0-5 group having knowledge of the therapy.

In pretest survey question six, 63% (n=13) of nurses had disagree responses whereas 19% (n=4) either agreed or strongly agreed that patients sitting in a chair should have resumption of compression therapy. Four nurses (19%) were neutral on this practice. Despite education, 19% (n=4) continued to either disagree or strongly disagree, 14% (n=3) remained neutral, and 67% (n=14) either agreed or disagreed on question six. In all experience groups, nurses were more divided on this topic as there were more neutral and disagree responses in the posttest compared to questions one and four.

Three themes were derived after analyzing the program evaluation form completed by 80% of the participating nurses. Fourteen nurses answered in open ended responses as to how they will change their professional practice after receiving the

education. Two nurses (14%) responded that they will give patients written information on the purpose of mechanical prophylaxis and advocate its use. Six (43%) stated they will utilize foot pumps as an alternative device and the remaining six (43%) of nurses responded that they will maintain compression therapy while patients are sitting in the chair. As a result, three themes emerged; 1) educating patients on the importance of mechanical prophylaxis and advocating its use, 2) knowledge of the A-V foot pump as an alternative compression device, and 3) defining immobility and adequate timing for mechanical prophylaxis.

Next, the summary and conclusions will be discussed.

Summary and Conclusions

The literature has revealed that compliance with mechanical prophylaxis among patients and nurses is variable (Brady et al., 2007). Nursing knowledge and attitudes have been found to influence adherence to VTE prophylaxis therapies (Elder et. al, 2016). Preventable complications can be averted by educating nurses on the importance of mechanical prophylaxis, including highlighting at-risk patients and appropriate timing of therapy. In addition, the economic burden and lifelong pain and suffering caused by DVT and PE could potentially be avoided. Prior research indicated that nurses desired to know more information on the appropriate and minimum application time of mechanical devices, the effectiveness of devices in preventing DVTs, and the difference in effectiveness between devices (Kim & Lee, 2015). The purpose of this project was to assess nurse understanding on the use and function of mechanical prophylaxis in VTE prevention.

This quality improvement project was created in response to a need for education on VTE prevention on a surgical unit at Rhode Island Hospital. This unit was identified as having poor compliance with mechanical prophylaxis by unit leadership. The Logic Model Framework, developed by the Kellogg Foundation, guided this quality improvement project. The framework allows the researcher to formulate and direct a transparent program where resources, activities, and intended outcomes are displayed in a diagram. As the program develops, the framework permits the program developer to adjust goals as organizational needs change.

A quality improvement project was developed using a pretest, intervention, post-test design. Institutional Review Board approval was obtained through Rhode Island College. An informational letter explaining the purpose of the program was delivered to the nurses in an e-mail one week before the pretest. Pretests were then made available to nurses to complete in the staff break room. The nurses were surveyed for one week and completed surveys were stored in a locked box to ensure confidentiality. The educational sessions began the following week and occurred twice daily for 30-35 minutes. The program learning objectives are outlined in Table 1. Immediately following the education, the nurses were surveyed using the posttest. The mean response rates of the pretest and posttest were analyzed to determine if the education enhanced understanding on the use and function of mechanical prophylaxis for nurses.

A total of 21 nurses participated in the pre and posttest for a 66% response rate. The mean response rate in the pretest was 3.6 compared to 4.3 in the posttest. The response rate increased by 0.7 points overall in the posttest, demonstrating increased understanding on the use and function of mechanical prophylaxis in VTE prevention. Portable information cards that included a sizing chart for both SCD and foot impulse boots and common alarm symbols with troubleshooting techniques were given to nurses at each education session.

After completing the education sessions, nurses were more likely to agree that they were formally trained on the use and function of mechanical prophylaxis. In addition, nurses who previously were not familiar with A-V foot pumps as a compression device now reported an understanding of this therapy including activation, troubleshooting, and sizing patients correctly. Nurses were also familiarized on

contraindications to the device and appropriate timing of therapy, which proved to be the greatest learning need for nurses with 0-5 years of experience. Lastly, although nurses were more likely to agree that patients sitting in a chair should have their compression device maintained in the posttest, more nurses remained neutral after the education was provided. Nurses with less than 10 years of experience were more likely to agree that they will maintain compression therapy while patients are sitting in a chair.

While the participation in the program and the pre and posttest was satisfactory, there were limitations to the program. The program occurred during the week of a hospital-wide Joint Commission survey. This proved to be less than an optimal time to conduct an educational program as nurse leadership and nurses were preoccupied with survey preparation. As a result, two afternoon sessions were cancelled by nurse management. In addition, patient census throughout the hospital was high and remains continuously high, putting greater demands on staffing. Most nurses could not allot 30-35 minutes of their time to the education. Some sessions had to be condensed to meet scheduling constraints. In the future, it may be necessary to designate free time for nurses to attend education on this topic, such as in annual clinical competencies which tend to be mandatory and held during non-work time. The number of nurses who were out on leave of absences and the effect attendance had on the participation rate is also unknown. Lastly, the results of this program reflect the experience of nurses on one unit. Further research is needed to determine nurse understanding on the use and function of mechanical therapy hospital-wide to understand the larger impact on patient outcomes.

Despite the small sample size, this quality improvement project demonstrated improved nurse understanding on the use and function of mechanical prophylaxis after

participating in the program. Further research is needed to determine if providing nurse education using this program will increase compliance with sequential compression devices (SCD) and foot pumps. Providing this education to supportive staff, such as certified nursing assistants with direct patient care contact, could also promote greater compliance and should be explored.

Recommendations and Implications for Advanced Nursing Practice

As an advanced practice nurse, the Adult/Gerontology Acute Care Nurse Practitioner (AGAC-NP) is positioned to care for complex patients, anticipate potential complications, and prevent unnecessary harm. In the advanced practice role, the nurse practitioner (NP) must stay up-to-date with current practice recommendations and analyze modern research to improve his/her own practice standards. Translating research into daily practice is challenging and takes the concerted effort of a team. While the NP's role as an educator may not be as evident to some, NPs must support RNs caring for patients in the acute care setting by acting as role models in bringing evidence-based practice (EBP) to the bedside.

Nurse practitioners can reduce hospital-acquired events by participating in protocol development and education. To meet national patient-safety goals, VTE prevention protocols are necessary to support positive patient outcomes, reduce hospitalizations and expenses. Nurse practitioners serving the medical-surgical population must be in tune to patient risk factors for VTE and advocate for prophylactic therapy. They should also participate in root cause analysis to determine the original contributor of VTE events within an organization and provide quality and safety personnel with the current practice recommendations to guide education. Nurse practitioners can be involved in creating order sets, which clearly state goals of therapy, including minimal application time and indications for removal. An order may state to maintain compression therapy for 18 hours during waking hours, as recommended by the AHRQ and to remove at night to promote sleep hygiene. Removing therapy during nighttime hours may increase patient comfort and compliance with mechanical therapy.

The lack of nursing policy on the use and function of mechanical prophylaxis at Lifespan may be contributing to reduced compliance among nurses. Ultimately, nursing practice inconsistencies directly affect patient outcomes. Incorporating technology such as automated practice reminders for nurses within the electronic charting systems could promote mechanical therapy usage. In addition, screening patients for risk factors upon admission can alert nurses to make patient VTE prevention a priority. To encourage patient use, hospitals can invest in newer technologies that support patient comfort. Kendall's new, soft compression sleeve is designed to give patients greater range-of-motion and maximum breathability. Policy efforts at the national level must also push for public safety awareness on the seriousness of VTE. Campaigning initiatives that identify persons at high risk, such as having a family member with a history of VTE or undergoing surgery, can alert the public on the importance of prevention. A more informed population will advocate for proactive care and in return will help minimize complications and help reduce the economic burden of VTE.

The goal of this quality improvement project was to assess surgical nurses' understanding on the use and function of mechanical prophylaxis. Nurses with 0-5 years of experience made up the majority of those caring for patients at the bedside. More hospitals are mandating a baccalaureate degree for entry level positions, as recommended by the National Academy of Medicine. Current research supports defining the Bachelor of Science in Nursing (BSN) as the minimal education requirement for nurses. BSN-prepared nurses and those with higher degrees, are more likely to have experience interpreting and implementing research into daily practice. As the average life-expectancy of Americans rises, more people are living with chronic illnesses. Nurses with

advanced degrees are needed to care for the growing number of older, more complex patients.

The nursing profession is often chosen as a second career and is comprised of people of all age groups, cultures and educational backgrounds. Additional research is needed to understand the various learning styles among members of different generations. Educational programs must be built to meet the needs of a diverse nursing population and must encompass multiple approaches to maximize comprehension. Further research is needed to determine if by mandating such a program during new hire orientation or in yearly competencies would increase compliance with mechanical prophylaxis and decrease VTE events hospital-wide. The benefits of educating physicians and advanced practice providers (APP) practitioners on mechanical delivery systems are unknown. Educating all team members involved removes the burden of preventative care on a sole provider and creates a shared responsibility among members of the interdisciplinary team.

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Appendix A

(Pretest)

How long have you been an RN? _____

How long have you been on your current nursing unit? _____

I have been formally trained on the use of sequential compression devices (SCD).				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am confident in my knowledge on when it is appropriate to use an SCD.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I can state at least one contraindication to using an SCD.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am familiar when to use foot pumps as an SCD device.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I routinely check for an order for mechanical prophylaxis.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
When a patient is sitting in the chair, I maintain the SCD.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I educate my patients on the purpose of SCD therapy.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am confident in determining when a patient no longer requires SCD therapy.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I discontinue the SCD when my patient is able to ambulate down the hallway, three times a day.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I consistently document the use of SCD at a minimum of 24 hours.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Appendix B

(Posttest)

How long have you been an RN? _____

How long have you been on your current nursing unit? _____

I completed the first survey before participating in this educational program. Yes or No

I have been formally trained on the use of sequential compression devices (SCD).				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am confident in my knowledge on when it is appropriate to use an SCD.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I can state at least one contraindication to using an SCD.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am familiar when to use foot pumps as an SCD device.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I routinely check for an order for mechanical prophylaxis.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
When a patient is sitting in the chair, I maintain the SCD.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I educate my patients on the purpose of SCD therapy.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am confident in determining when a patient no longer requires SCD therapy.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I discontinue the SCD when my patient is able to ambulate down the hallway, three times a day.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I consistently document the use of SCD at a minimum of 24 hours.				
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

Appendix C

Individual Educational Activity Evaluation Form

Rhode Island Hospital

Nurse Educational Program on the Use and Function of Mechanical Prophylaxis

October 2017

1. The **learning outcome(s) for this activity** was met: The desired outcome is improved nurse competency on the use and function of mechanical prophylaxis and to promote adherence of mechanical devices.
 Strongly Agree Neutral Disagree Strongly Disagree

2. I found this activity worthwhile for my professional practice. (If you select “Disagree” or “Strongly Disagree,” please provide a comment below.)
 Strongly Agree Agree Neutral Disagree Strongly Disagree

3. This activity will enhance my knowledge/skill /practice as a health care provider. (If you select “Disagree” or “Strongly Disagree,” please provide a comment below.)
 Strongly Agree Agree Neutral Disagree Strongly Disagree

4. **SPEAKER EVALUATION**

Speaker Name:	Speaker Topic:
The speaker was knowledgeable about the topic:	
<div style="display: flex; justify-content: space-around;"> Strongly Agree Agree Neutral Disagree Strongly Disagree </div>	
The speaker provided the information in an interesting manner that facilitated my learning:	
<div style="display: flex; justify-content: space-around;"> Strongly Agree Agree Neutral Disagree Strongly Disagree </div>	

5. As a result of this activity, please share at least one action you will take to change your professional practice/performance.
6. What other health care/professional topics would you like to see presented?
7. Comments: